ing to embodiments of the present invention, and shows the relationship of single carrier frequency-division multiple access (SC-FDMA) symbols, subcarriers, resource blocks and resource elements.

[0012] FIG. **2**B illustrates an uplink resource grid showing a resource configuration that may be used in systems according to embodiments of the present invention, and shows the relationship of orthogonal frequency-division multiplexing (OFDM) symbots, subcarriers, resource blocks and resource elements.

[0013] FIG. **3** illustrates joint transmission cooperative multi-point operation by elements that may be used in an embodiment of the present invention.

[0014] FIG. **4** shows a simplified block diagram of various electronic devices that are suitable for use in practicing embodiments of this invention.

[0015] FIG. **5** presents a table showing mapping from a channel state information (CSI) reference signal configuration to (k', l') for a normal cyclic prefix.

[0016] FIG. **6** illustrates a prior-art channel state information reference signal (CSI-RS) configuration for two transmission points (TP**1** and TP**2**).

[0017] FIG. **7** illustrates a channel state information reference signal (CSI-RS) configuration Table illustrating configuration of an additional two transmission port CSI-RS resource shared by two transmission points as compared to the approach illustrated in FIG. **5**.

[0018] FIG. **8** presents an exemplary codebook for transmission on antenna ports {**0**,**1**} and for channel state information (CSI) reporting based on antenna ports {**0**,**1**} or {**15**, **16**}.

[0019] FIG. **9** illustrates an exemplary use of precoding matrix indicator (PMI) feedback for indication of a phase difference between two antennas each associated with one transmission point of a pair of transmission points.

[0020] FIG. **10** illustrates a process according to one or more embodiments of the present invention.

[0021] FIG. **11** illustrates a transmission point configuration according to one or more embodiments of the present invention.

[0022] FIG. **12** illustrates a process according to one or more embodiments of the present invention.

DETAILED DESCRIPTION

[0023] One modern communication system is known as evolved UTRAN (E-UTRAN, also referred to as UTRAN-LTE or as E-UTRA). In this system the downlink (DL) access technique is OFDMA, and the uplink (UL) access technique is SC-FDMA.

[0024] One specification of interest is 3GPP TS 36.300 V11.0.0 (2011-12) Technical Specification 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2 (Release 11).

[0025] FIG. **1** illustrates the overall architecture a system **100**, such as a E-UTRAN system, in which one or more embodiments of the present invention may be used. The system **100** includes network access nodes or base stations which may be implemented in the form of eNodeBs (eNBs) **102**A, **102**B, and **102**C, and which may provide an E-UTRAN user plane and control plane (radio resource control (RRC)) protocol terminations towards user devices, which in an embodiment may be implemented as user equipments (UEs), here UEs **104**A and **104**B. The eNBs **102**A-**102**C may be interconnected with one another by means of an X2 interface **106**. In addition or as an alternative to using the logical X2 interface, for cooperative multi-point (CoMP) operation, other inter-transmission point connections such as optical or other non-standardized low-latency, high capacity interfaces may be used. The eNBs **102**A-**102**C may also be connected by means of an S1 interface to an evolved packet core (EPC). In an embodiment, the connection may take the form of S1 mobility management entity (S1 MME) interface **108** to MME serving gateways (MME/S-GWs) **110**A and **110**B. The S1 interface **108** supports a many-to-many relationship between MMEs, S-GWs and eNBs.

[0026] Uplink and downlink frames (of 10 msec duration) are defined in 3GPP TS 36.211 V10.4.0 (2011-12) Technical Specification 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); Physical Channels and Modulation (Release 10). FIG. **2**A illustrates an uplink resource grid **200** presenting an exemplary definition of resources that may be used in a system such as the system **100** of FIG. **1**, and showing the relationship of SC-FDMA symbols, subcarriers, resource blocks and resource elements. The grid comprises a plurality of uplink slots, exemplified by the slot **202**, which is a time slot. One or more of the uplink slots may carry single carrier frequency-division multiple access (SC-FDMA) symbols, and the grid may be arranged horizontally from I=0 to some maximum, which in the present example may be $I=(N_{symbl}^{UL})-1$, and from k=0 to some maximum, which in the present example may be $k=(N_{RB}^{UL})(N_{SC}^{RR})-1$. The grid may comprise a resource block comprising, for example, a number $(N_{symbl}^{UL})(N_{SC}^{RB})$ of resource elements. The overall grid may comprise $(N_{RR}^{UL})(N_{SC}^{RR})$ subcarriers, while the resource block may comprise (N_{SC}^{Rb}) subcarriers.

[0027] FIG. **2**B illustrates a downlink resource grid, showing the relationship of OFDM symbols, subcarriers, resource blocks and resource elements. The resource blocks can be referred to as physical resource blocks (PRBs). The grid comprises a plurality of downlink slots, exemplified by the slot **252**, which is a time slot. One or more of the downlink slots may carry orthogonal frequency-division multiplexing (OFDM) symbols, and the grid may be arranged horizontally from 1=0 to some maximum, which in the present example may be $I=(N_{symb}^{RDL})-1$, and from k=0 to some maximum, which in the present example may be $k=(N_{RB}^{DL})(N_{SC}^{RB})-1$. The grid may comprise a resource block **204** comprising, for example, a number $(N_{symb}^{DL)(N_{SC}^{RC}})$ of resource elements such as the resource element **206**. The overall grid may comprise $(N_{RB}^{DL}(N_{SC}^{RB})$ subcarriers, while the resource block may comprise (N_{SC}^{RB}) subcarriers.

[0028] One CoMP scheme is referred to as coherent joint transmission (JT) CoMP. In coherent JT CoMP, data is jointly transmitted to a UE from multiple transmission points. Based on CSI feedback from the UE a base station such as an eNB is able to precode the data so that the received signal quality (for example, signal to interference plus noise ratio (SINR), throughput, or both, or some alternative or additional characteristic or combination of characteristics) is maximized. To provide the information needed to accomplish this precoding, the eNB needs to be able to obtain information not only about a preferred precoder for each participating transmission point, but also information descriptive of a phase difference